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THE RELATION
BETWEEN THE
RESPIRATORY AND CIRCULATING
FUNCTIONS.

BY CHARLES HOOKER, M.D.

READ AT THE ANNUAL NEW HAVEN COUNTY MEETING OF THE CONNECTICUT
MEDICAL SOCIETY, APRIL 12, 1838.

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AN ESSAY

ON

THE RELATION BETWEEN THE RESPIRATORY AND CIRCULATING FUNCTIONS.

THE general relation between the respiratory and circulating functions has long been known. It is unquestioned that the main office of the lungs is to effect that change in the blood which constitutes the difference between venous and arterial blood ; and that the sole office of the right side of the heart is to transmit the blood to the lungs for the purpose of this change. This process has been called *oxygenation*, *decarbonization*, &c., according to different theories by which it is explained ; also *arterialization*, a term implying no theory, but simply the fact that the blood is thus prepared for circulation through the arteries ; and *aeration*, which simply implies that this change is effected by an exposure of the blood to air in the lungs.

RELATIVE FREQUENCY OF THE RESPIRATION AND THE PULSE.

From what is known of the philosophy of the process of aeration, it is reasonably inferred that a proper balance is required between the two functions of respiration and circulation, or, in other words, between the quantity of air respired, and that of the blood circulating through the lungs. It might further be inferred that, in a healthy condition of the organs, a definite ratio is observable between the frequency of the respiration and of the pulse. As a general rule, this ratio may be stated as *one to four and a half*—that is, in a healthy, well-formed adult, when the pulse is 70 in a minute, the number of respirations is about 15 or 16 ; while, if the pulse is naturally more or less than 70, there is a proportionate frequency of the respiration. So, in case of general febrile excitement, if the pulse is increased in frequency, a proportionate increase of the respiration is required to preserve a due balance between the two functions. In disease, however, it is very common that this balance between the functions is not preserved, and there are many variations in the ratio between the respiration and the pulse.

The object of this essay is to trace the diagnostic, pathological, and therapeutic indications of these variations.

That this subject has heretofore received little attention, is evident from the fact, that the few authors who have adverted to it, are not agreed even in regard to the natural ratio between the respiration and the pulse.

This ratio is stated by Haller to be as 1 to 3 or 4; by Dr. Graves, as 1 to 4. The number of respirations in a minute, in a healthy adult, is estimated by Magendie as 15; by Dr. Dunglison, about 18; by Sir Humphry Davy, 26 or 27; while Dr. Good, Dr. C. J. B. Williams, and most other writers, give 20 as the ordinary number. Supposing the latter to be the true number, and the pulsations, as commonly estimated, to be 70 in a minute, the ratio will be 1 to $3\frac{1}{2}$; while, according to the estimate of Sir Humphry Davy, the ratio is about 1 to $2\frac{1}{2}$.

This discrepancy of statements plainly shows, that the observations of authors on this point have been very limited. The only method which will lead to correct conclusions, a method which I have frequently practised since my attention was turned to this subject, is to count the respiration of persons who are not aware of such observation; for, as the respiration is much under the control of the will, its frequency will be varied by the operation of the mind. Hence, a conclusion drawn from observing one's own respiration would be liable to error. Perhaps diversity of climate, and national peculiarities of constitution, may occasion some variation from the ratio which I have stated; but so constant has been this ratio, of 1 to $4\frac{1}{2}$, according to my observation, that I have regarded any considerable variation from it as a pretty sure indication of malformation or disease. In a diagnostic and pathological point of view, therefore, I regard the *comparative frequency* of the respiration and the pulse as highly important.

In early infancy there is less regularity in this ratio. Owing to imperfect development of the lungs, or some other cause, it is not uncommon that an infant, with a pulse of 120 or 130, will have 40, 50, or even 60 respirations in a minute. Generally, however, the healthy ratio becomes established in the course of the first or second year. So in adults, the respiration is rendered frequent by many circumstances which can hardly be considered as disease. Obesity, by preventing a free and large expansion of the chest, gives occasion to increased frequency of the respiration. The same effect is produced by a distension of the stomach or intestines, by pregnancy in females, and by any circumstance which prevents a free descent of the diaphragm. Any circumstance,

indeed, that prevents a full quantity of air from being received into the lungs with each inspiration, necessarily calls for more frequent respiration. As a general rule, if the respiration is deficient in fullness, the deficiency is compensated for by increased frequency.

DIAGNOSTIC INDICATIONS OF A DISPROPORTIONATE FREQUENCY OF THE RESPIRATION AND THE PULSE.

The general diagnostic indications afforded by variations of the ratio between the respiration and the pulse, may be reduced to two heads.

1st. A disproportionate *increased* frequency of the respiration indicates,

A. Disorder of the lungs or air passages.

B. Some mechanical impediment to the motions of respiration : or,

C. Imperfect function of the organic nerves of the lungs.

2nd. A disproportionate *diminished* frequency of the respiration indicates a want of energy in the nerves which control the respiratory motions.

1st. A. *Frequent Respiration from Disorder of the Lungs or Air Passages.*

It is obvious why disease of the lungs should occasion a disproportionate increased frequency of the respiration. If by engorgement, hepatization, tubercular deposition, or other disease, a portion of lung is rendered unfit for respiration, the remaining healthy portion, having the whole office of aeration to perform, must act with increased frequency in order duly to arterialize the blood. If, for instance, only one half of the lungs is fit for respiration, the frequency must be doubled. Thus, in acute diseases of the lungs, the ratio between the respiration and the pulse may be considered as some criterion of the *amount* of pulmonary obstruction. In cases, however, attended with either depression or exhaustion of nervous energy, as we shall hereafter notice, this criterion must be received with some allowance.

Frequent respiration in pneumonitis.—The relative frequency of the respiration in pneumonitis is one of the most constant symptoms of the disease. As in other febrile diseases, the pulse is commonly frequent, but the increased frequency of the respiration is altogether disproportionate to that of the pulse. In cases of extensive engorgement, it is not uncommon that the respiration is 45 in a minute, when the pulse does not exceed 90 ; the ratio becoming as 1 to 2. In extreme cases, the respiration becomes even 60 or 70 ; and in children I have occa-

sionally noticed it 140 or 150. In less degrees of engorgement, the ratio is as 1 to 3, $3\frac{1}{2}$, or 4.

Commonly the pain in the chest, cough, and other symptoms, sufficiently indicate the general character of the disease. In some *latent* cases, however, these general symptoms are wanting; and there is scarcely a single symptom indicating pulmonary disease, except the comparative frequency of the respiration.

A single case may be adduced, as an example of the importance of the ratio between the respiration and the pulse, as a diagnostic indication in such cases.

In March, 1832, I was one morning called to visit a vigorous young man, who had been attacked, the night previous, with chills, succeeded by considerable heat and febrile excitement. The skin was now cool, the tongue slightly furred—no pain or soreness in any part of the system, no disturbance of the stomach or bowels, no cough or expectoration, nor was the patient sensible of any difficulty of respiration. The pulse was 78, the respiration 30. This disparity between the pulse and the respiration was the only apparent general symptom of local disease—a symptom which probably would not have been noticed, but for my constant habit of attention to this point. The patient had not been subject to habitual shortness of breathing, and strict inquiry gained no clue to the existing disease. But the abnormal ratio between the respiration and the pulse (about 1 to $2\frac{1}{2}$) warranted a suspicion of disease within the chest; and, on applying auscultation and percussion, it directly appeared that the lateral and posterior portions of the right lung were extensively engorged—in short, there was a *latent pneumonitis*, occupying a greater part of the right lung. A large blister was applied to the affected side, and calomel, elaterium, sanguinaria, and other remedies which had proved serviceable in the pneumonitis of that season, were perseveringly administered. The disease continued day after day to run a perfectly latent course; and the nurse, a judicious elderly lady conversant with disease, was very distrustful of my diagnosis, saying that she had “always seen lung fever attended with pain in the chest, cough, difficulty of breathing and expectoration.” At the commencement of the 6th day of the disease, I was called to my patient in the night. The nurse met me at the door, exclaiming, “now, doctor, I believe you—the man has lung fever.” The symptoms at this time were a severe pain in the affected side, a laborious, rattling respiration, and a copious bloody expectoration. The disease was now making a crisis, and the patient gradually convalesced. Whether this favorable result would have occurred is very

doubtful, had not the treatment been directed by an early correct diagnosis.

We often hear of similar irregular cases of disease, which are described as "typhoid fever," or "general debility," which continue for 6 or 7 days, when a "pneumonia sets in" and carries off the patient. In such cases, attention to the comparative frequency of the respiration and the pulse would always lead to investigation for disease of the respiratory organs.

Frequent respiration in phthisis.—In the early stages of *phthisis*, this disparity between the respiration and the pulse may be regarded as one of the most valuable signs. It is not uncommon, in this disease, that considerable tubercular deposition in the lungs takes place, before the occurrence of cough, expectoration, and many other of the ordinary symptoms of the disease. Frequently, indeed, there are no prominent general symptoms, except, perhaps, a progressive debility and emaciation. With these symptoms, a disproportionate increased frequency of respiration affords a strong presumption of tubercular deposition. A simple general debility increases the frequency of respiration; but it occasions a proportionate increased frequency of the pulse—the ratio of 1 to $4\frac{1}{2}$ is still preserved. Whereas, if the lungs are obstructed by tubercles, the respiration is out of proportion to the pulse.

In this disease the abnormal ratio between the respiration and the pulse is a more uncertain criterion of the *amount* of pulmonary obstruction than in *acute* diseases; for the scrofulous affection which produces the tubercular deposition in the lungs, at the same time impairs the processes of digestion and sanguification—hence, the quantity of blood in the system is much less than in health, the pulse is weak, and each contraction of the heart sends a small quantity of blood to the lungs; the quantity of blood to be aerated in the lungs is, therefore, less than natural, and a smaller quantity of air is required in respiration. In advanced stages of *phthisis*, there is so little blood in the system, that a very small proportion of healthy lung is sufficient for its arterialization, with only a moderate acceleration of the breathing. I have examined subjects who had died of this disease, in whom scarcely a tenth part of the lungs appeared to have been fit for respiration; when, a few days before death, with a pulse of 130 or 150, the respiration had not exceeded 35 or 40. Were the lungs obstructed to this degree in acute diseases, with a full quantity of blood in the system, an immeasurably increased frequency of respiration would be required to sustain life. But in the progress of a lingering case of *phthisis*, the quantity of blood in the

system ; the size of the aorta and other arteries, which are sometimes diminished in calibre nearly one half ; and the feeble imperfect contractions of the heart, all become accommodated to the small remaining portion of healthy lungs.

I should here notice some incidental remarks in the clinical lectures of Dr. Graves, of the Meath Hospital, Dublin, which seem to be the result of imperfect observation. He remarks, "I have seen many cases of phthisis, in which there was accelerated breathing, with slow pulse, but these were always cases of a chronic kind. I have never observed the same phenomena existing when the disease was acute ; it is a state of things which is compatible only with chronicity of disease." In *acute* pulmonary disease, he says, when the respiration is considerably accelerated, there is "a corresponding increase in the frequency of the pulse." The very reverse of this is true. Certainly nothing is more common, in the early stage of acute pneumonitis, than to have the respiration 30, 40, or even 60 in a minute, when the pulse does not exceed 90. In acute œdematous inflammation of the lungs, I have often, within a few hours from the first attack, observed the respiration 70 or 80 in a minute—a mere panting—when the pulse scarcely exceeded its natural frequency. And in the early stages of phthisis, with a comparatively moderate tubercular obstruction of the lungs, I have commonly observed the disparity between the frequency of the respiration and the pulse greater than in the more advanced stages.

The observations and judgment of Dr. Graves are justly considered as high authority ; but he has evidently given little attention to this subject ; and he properly remarks, "I do not know any point on which accurate observations are more wanting, than on the proportion between the pulse and respiration in various states of the system, and in various diseases. Facts upon this subject might be easily collected, and would probably lead to curious and instructive results."

Frequent respiration in œdema of the lungs.—This disease is a very common cause of frequent respiration. Though the disease was noticed by Hippocrates, and has been more particularly described by Van Swieten, Darwin, Maclean, and others, most recent writers appear not to be aware of its common occurrence. Dr. Good barely notices it, as if doubting its occurrence. In treating of other dropsical affections within the chest, he says, "water is, *perhaps*, sometimes effused into the cellular texture of the lungs." Laennec says it is "rarely a primary and idiopathic disease. It comes on most commonly, with other dropsical affections in cachectic subjects, towards the fatal termination of long continued fevers, or organic affections, especially those of the heart."

It appears to me that the question, in regard to this affection, is to be resolved into the general one, whether any dropsy is a primary and idiopathic disease. I am certain that no part of the system is so commonly the seat of dropsy as the lungs; and, in general anasarca, it is commonly in the lungs that the disease is first manifested. Even those authors who appear to doubt the existence of such an affection as idiopathic œdema of the lungs, generally mention disordered respiration as a symptom of general anasarca.

There are many cases which appear to be intermediate between a proper inflammation and an acute dropsy of the lungs—cases which might be termed œdematous inflammation. Such cases certainly have claim to the character of a primary and idiopathic disease. Of this character was the prevailing affection of the lungs in the epidemic influenza in New Haven, in the winter of 1831–32. In many cases of that disease, extreme frequency of the respiration, as compared with the pulse, constituted almost the only symptom of thoracic affection.

In cases of chlorosis, in most of the chronic disorders of menstruation, in general debility, and in cachectic diseases generally, swelling of the ankles and other symptoms of general anasarca commonly occur. In almost all such cases I have found œdema in the lungs, before its manifestation in other parts of the system; and frequently the lungs are the only part in which it is to be observed. The affection can hardly fail to be injurious, by obstructing the lungs and interfering with a due aeration of the blood, and it is therefore very important to detect it in its early stages. Attention to the relative frequency of the respiration will afford suspicion of the disease; and a slight dullness observed on percussing the posterior portions of the chest after the patient has been lying on the back, or the same observed about the inferior lobes of the lungs after sitting or standing, with a dull respiratory sound corresponding to the dullness of percussion, will render the diagnosis almost certain. If the serum infiltrates into the air cells and the minute bronchia, as frequently occurs, especially when the affection has any thing of an inflammatory character, the stethoscope detects a sound like that produced by squeezing a wet sponge, by wringing wet clothes, or by the effervescence of fermenting liquors—a feeble and finer sound than the crepitation characteristic of proper inflammation.

Frequent respiration in various disorders of the lungs and air passages.—Besides the diseases already mentioned, any affection of the lungs, which prevents a portion of them from being freely permeated with air, necessarily occasions frequent respiration. Atrophy or emphy-

sema of the lungs, congenital imperfection of the organs, solidification or any other lesion consequent to former disease, or pulmonary apoplexy, may produce this effect. A like effect is produced by disorders of the bronchia or bronchial membrane, as mucous or other obstructions within the bronchia impeding the passage of air, or any affection of the bronchial membrane preventing a communication between the air and the blood within the lungs.

B. Frequent Respiration from some Mechanical Impediment to the Motions of Respiration.

Any disorder within the chest, exterior to the lungs, which affords a mechanical impediment to the expansion of the lungs, necessarily causes frequent respiration, as hydrothorax, pleuritic effusion, effusion into the pericardium, enlargement of the heart, aneurism of the aorta, or any tumor within the chest. The same effect is produced by ascites, flatulent distension of the stomach or intestines, or fullness of the abdomen from any other cause, operating to prevent a free descent of the diaphragm; hence a full meal occasions some acceleration of the breathing. Frequent respiration is caused also by any circumstance which renders a full inspiration painful, as rheumatism, or any inflammation of the intercostal or other muscles of respiration; or a like affection of the pleura, pericardium, heart, or any of the abdominal viscera. In peritoneal inflammation, the soreness and tumefaction of the abdomen render the respiration extremely short and frequent. Sometimes a debility of the respiratory muscles occasions the motions of respiration to be feeble, short, and frequent.

C. Frequent Respiration from Imperfect Function of the Organic Nerves of the Lungs.

In the function of respiration two important classes of nerves are chiefly concerned.

The *motions of respiration* are effected by that class which Sir Charles Bell terms *the respiratory system of nerves*. These nerves arise from the lateral portions of the medulla oblongata and upper part of the spinal cord. The functions of these nerves, and, of course, the motions of respiration, are performed without the aid of the will; but, by means of voluntary nerves distributed to the respiratory muscles, the will acquires some control over these motions.

The branches distributed to the lungs from *the great sympathetic nerve*, termed also *the ganglionic, or organic system of nerves*, are more

immediately concerned in *effecting the aeration of blood*. A full quantity of air in the lungs is inadequate to effect this change, without the influence of these branches of nerves. The motions of respiration, therefore, may be continued, through the influence of the former class of nerves, but if the organic or arterializing nerves cease to perform their office, the venous blood is returned unchanged to the left side of the heart, and thence transmitted to the system through the arteries. So if the function of these nerves is imperfect, the blood is in the same degree imperfectly arterialized.

These considerations explain reasonably how imperfect function of the organic nerves of the lungs occasions a relative frequency of respiration. Like organic disorder of the lungs, and the mechanical impediments to respiration, which have been adverted to, this nervous lesion operates to diminish the arterializing efficacy of each inspiration; and, consequently, a greater number of respirations is required.

The lesion of function of the organic respiratory nerves is considered, in this place, only as one of the causes of frequent respiration: the pathological effects of this lesion, in preventing a due arterialization of the blood, will be considered under our second general head, in connection with the subject of imperfect function of the motor respiratory nerves.

General diagnostic indication of increased frequency of respiration.

From the preceding considerations it may be inferred, that a disproportionate increased frequency of respiration does not indicate the particular disease which impedes the respiratory function. The impediment may be some disorder of the lungs or air passages, or some mechanical impediment to the motions of respiration, or an imperfect function of the organic nerves of the lungs. The frequency of breathing only affords the general indication, that there is some impediment to the respiration, the particular cause of which is to be investigated by attention to the symptoms, and by auscultation, percussion, and other means of exploration. Attention to this general indication will, in many cases, enable the practitioner to adapt his remedies successfully to local diseases, which otherwise might altogether elude observation, and lead to serious and even fatal results.

2d. *A disproportionate diminished frequency of the respiration indicates a want of energy in the nerves which control the respiratory motions.*

A lesion of function in either of the two classes of nerves principally

concerned in respiration, occasions a disparity between the respiratory and circulating functions, and causes imperfect aeration of the blood. Imperfect function of the *motor* respiratory nerves produces this effect, by causing a disproportion between the quantity of air respired, and that of the blood circulating through the lungs. Imperfect function of the *organic* or *arterializing* nerves produces the same general result, by impairing the influence of the respired air on the blood. In the former case the quantity, in the latter the effect, of the respired air is diminished. As the pathological effects are in general the same, it is proper to consider in connection, A. Imperfect aeration of the blood from disordered function of the *motor* respiratory nerves; and, B. Imperfect aeration of the blood from disordered function of the *organic* respiratory nerves.

GENERAL PATHOLOGICAL EFFECTS OF IMPERFECT AERATION OF THE BLOOD.

The celebrated French physiologist, Bichat, was the first who drew the attention of physicians to any satisfactory knowledge of the pathological effects of imperfect arterialization of the blood. He found, by experiments, that if a current of venous blood is turned into the carotid arteries, it produces torpor of the brain. A moderate quantity of black blood thus transmitted to the brain, produces a degree of stupor and drowsiness. A large quantity produces loss of sensation and voluntary motion, and occasions coma and death. By turning, in the same manner, a current of venous blood into the main artery supplying one of the limbs, he found it to occasion a numbness and paralysis of the limb. In short, if venous blood is made to circulate through any artery of the system, it occasions a torpor of the part supplied by such artery. If the function of the lungs ceases, while the heart continues to act, the blood not arterialized circulates through the whole system, occasioning a general torpor, paralysis, and death.

The effects caused by a cessation of the respiratory function, are termed *asphyxia*. The general phenomena of asphyxia produced by a sudden cessation of the respiratory function, as in hanging, drowning, &c., are well known—the heart continues to act, sending the black blood into the arteries which naturally circulate red blood; the skin and all parts of the system assume a livid color; consciousness, sensation and voluntary motion are suspended; and, with the cessation of the heart's action, death ensues. Similar phenomena occur in most diseases at the close of life; and, in the opinion of Bichat, asphyxia is by far the most

common immediate cause of death. "Whatever may be the seat of the principal disease," he says, "whether it be an organic defect, or a general injury of the functions, as fever, &c., almost always, in the last moments of existence, the lungs are embarrassed; respiration becomes painful; the air is taken in and expelled with difficulty; the coloration of the blood is hardly carried on; it passes nearly black into the arteries. The organs, already debilitated by disease, receive much more easily in that state the fatal influence of the contact of this blood, than in asphyxia where they are unaffected. The loss of sensations and of intellectual functions, and very soon that of voluntary motions, succeed the embarrassed state of the lungs. The man has no longer any connection with surrounding objects; his whole animal life is interrupted, because the brain, which, as it is known, governs this life, penetrated with black blood, ceases its functions. By degrees the heart, and all the organs of internal life, imbibing this blood, cease their motions also. In this case it is the black blood which altogether stops the vital motions already enfeebled by the disease. It is in general very rare that debility produced by disease brings on death in an immediate manner; it paves the way to it, and renders the organs susceptible of being influenced by the smallest change in the red blood. But it is almost always this change which puts an end to life. The cause of the disease is therefore only an indirect cause of general death; it occasions that of the lungs, which latter brings on that of all the organs."—(*Treatise on Life and Death.*)

These views of Bichat, in regard to the deadening influence of the black blood on those parts of the system which are naturally supplied with red blood, are now commonly received by pathologists. Perhaps this influence is not so generally the immediate cause of death, as this author supposed; but it is probably true, that death is most commonly produced in this way. Since the publication of Bichat, the subject of this influence has received considerable attention, particularly as an immediate precursor and cause of death; while but little attention has been given to a less degree of the same influence observable in the progress of many diseases. Throughout the progress of some diseases, particularly fevers of a typhous character, this relation between the respiration and circulation appears to have a most important influence, a correct understanding of which, it is believed, will lead to many important therapeutic indications.

A. Imperfect Aeration of the Blood from Disordered Function of the Motor Respiratory Nerves.

A lesion of function of the respiratory system of nerves *impairs the motions of respiration*, causing the respiration to be infrequent and small ; and in consequence, less than a natural quantity of air is respired. In this condition of the respiration, if the circulation continues strong, a disparity between these two functions occurs ; the air respired is insufficient duly to aerate the blood in the lungs ; and consequently the blood passes into the system imperfectly arterialized.

The deleterious effects of such impaired function of the respiratory nerves may be estimated from a consideration of the well known deadening influence of the black blood in extreme cases of asphyxia. The imperfectly arterialized blood, though still retaining enough of its arterial character to sustain life, occasions a degree of torpor in the brain and all parts of the system supplied by the arteries. Sensation, consciousness, voluntary motion—all the cerebral functions—become impaired. The capillary vessels, partially paralyzed, become distended and engorged with dark colored blood ; the lips and finger nails have a livid tinge, a livid paleness pervades the whole surface, and the florid hue of health is nowhere seen. Secretion and absorption become affected ; passive engorgements take place in various parts ; indeed, a torpor produced by the deadening influence of the imperfectly arterialized blood pervades the whole system. The respiratory nerves, in common with other parts of the system, become affected with this torpor, which, by rendering the respiratory motions more languid, tends still further to impair the arterialization of the blood, which again reacts on the respiratory nerves. As the degree of this influence increases, the cerebral functions become more oppressed, and symptoms of approaching dissolution appear, such as subsultus tendinum, coma, colliquative discharges, and frequently tympanitic distension of the abdomen.

Typhous fever.—Something of the train of symptoms above described ordinarily occurs in typhous fever, and in other diseases of a typhoid character. The lesion of nervous function in the brain, which is a prominent characteristic of typhoid diseases, almost always extends to the respiratory system of nerves, occasioning a disparity between the respiration and the circulation. While the healthy ratio between the respiration and the pulse is 1 to $4\frac{1}{2}$, in typhous fever it is commonly 1 to 5 or 6, and in many cases 1 to 7 or 8. The respiration, though often more frequent than in health, is not proportionate to the increased frequency of the pulse ; and if the pulse is less frequent than natural, as some-

times occurs, there is more than a proportionate infrequency of the respiration. In most cases this relative infrequency of the respiration continues through the whole course of the disease, and during the last seven years I have never seen a case of simple typhus in which it was not remarkable in some stage of the fever.

It is true, that in this disease the heart partakes of the attending general debility, and in consequence, its action being feeble, less blood is thrown to the lungs by each contraction; from which it might seem that, notwithstanding the relative infrequency of respiration, the blood may be sufficiently arterialized. On the contrary, however, it may be observed, that the respiratory muscles also partake of this general debility, and in consequence the respiration is feeble and small. In general, I think, the smallness of the respiration is more than proportionate to that of the pulse, so that the deficiency of arterialization is even greater than is indicated simply by the infrequency of respiration.

That the blood is imperfectly arterialized in typhus, is sufficiently evident from the symptoms of the disease. Dr. Armstrong, in giving the distinguishing signs of common continued fever and typhus, says, that "In the common continued fever, the patient commonly has not much inaptitude of mind, often answers questions readily, and in a pretty firm voice, without much increased agitation of the breathing; whereas in typhus the answers are mostly given with languid slowness and reluctance, and much speaking obviously disturbs the respiration. In the common continued fever the skin is generally of a brighter red than natural, especially on the cheeks; on the contrary, the skin is always more or less of a dusky color in typhus, and an admixture of it may be best observed in the flush of the face. This duskiness of the skin is one of the proper symptoms of typhus, and seems to arise from some change in the constitution of the blood, which I have almost invariably seen darker on dissection than in ordinary fevers. In the worst cases, this duskiness increases in the progress of the disease, and lessens in those that assume a mild aspect. So very characteristic is this cutaneous duskiness, that I think I could distinguish typhus by it at any time, if two patients were presented to me, the one laboring under that disease and the other under the common continued fever."—(*On Fever*, p. 235.)

In another part of his treatise (p. 410), Dr. Armstrong observes, "The blood is always blacker in typhus than natural. In severe cases it is remarkably so where the excitement is fully emerged, and at last the solids are most decidedly affected, as any one may perceive who marks the dark hue of the muscles on dissection. This state of the

blood in typhus, if I mistake not, is connected with that peculiar depression of strength, and with the peculiar condition of the sensorium, which attend the rise and progress of this disease. But," continues Dr. Armstrong, "the nature of this change in the blood, I do not pretend to determine, and only meant to point to it as an object worthy of far more attention than it has yet received."

Dr. Southwood Smith says, "The skin is always of a darker color than in synochus; the whole surface is of a dull and dusky tinge."—(*On Fever*, p. 166.)

The dark color of the blood in typhus is noticed by other authors, as of common occurrence. That it "is *always* blacker than natural," as asserted by Dr. Armstrong, is questionable. Though I have always observed, in some stages of the fever, a relative infrequency of respiration, with the dark colored blood, and other symptoms necessarily attending this imperfect respiration; yet I have noticed, in the commencement or progress of some cases, an occasional acceleration of the breathing, continuing for several hours or even days, during which the cheeks assumed a florid color, and there was every indication of perfect aeration of the blood. Sometimes there is even a morbid frequency of respiration apparently depending upon irritation of the respiratory nerves, during which the skin is uncommonly florid, and there is morbid wakefulness and sometimes a phrenzied delirium. Such a state, however, is ordinarily of short continuance, and is succeeded by infrequent respiration, lividity of skin, a low delirium, subsultus tendinum, and coma—the irritative excitement being succeeded by a morbid depression of nervous energy.

No inconsiderable part of the symptoms occurring in typhus, it is believed, may be attributed to the imperfect respiration which we are considering. The "sensorial debility and disturbance of the mental powers," which are prominent characteristics of typhus, may be produced by any impediment to the respiration, preventing a proper aeration of the blood. But it is not to be supposed that this imperfect respiration is ordinarily the first link in the chain of disease in typhus. It is preceded and caused, in most cases, by a torpor of the respiratory system of nerves, which appears obviously connected with a general depression of nervous energy throughout the system. In such cases, however, the imperfect respiration cannot fail to add to the general nervous torpor, through the paralyzing influence of the black blood; and in cases of disease commencing in the lungs, a similar torpor of the nervous system is a consequent result.

I have adverted particularly to typhous fever, as a disease in which this deficient arterialization of the blood is ordinarily prominent throughout its progress. In this disease there is hardly a point requiring more careful observation for prognostic and therapeutic indications. A remarkable relative infrequency of respiration, in the early stage of the disease, indicates an alarming prognosis. If in this stage the respiration and pulse are as 1 to 7 or 8, it is almost certain that its course will be of a low typhoid character. Vertigo, tinnitus aurium, subsultus, a muttering delirium, and coma, are almost sure to succeed. If such infrequency of respiration occurs in any stage of the disease, it may be considered as the precursor of a similar train of symptoms. Those symptoms which are commonly attributed to "determination to the brain" or "congestion in the brain," are associated with, and in a great measure depending upon, this imperfect respiration.

Congestive typhus.—In that form of disease which is treated of by Armstrong and others as congestive typhus, this deficiency of respiration appears to be a prominent cause of the peculiarities characterizing this form of fever.

This variety of typhus is commonly ushered in with chills, vertigo, drowsiness, and extreme general prostration; the breathing is infrequent, irregular and sighing, or in some cases frequent, but short, feeble and inefficient; the skin pale and somewhat livid; the heat of surface unequally diffused; the pulse rather frequent and irregular, or in some cases very infrequent and oppressed; sensation and voluntary motion are suddenly impaired; and subsultus, muttering delirium, and coma, soon supervene. In rapid cases the disease has a near resemblance to apoplexy. On dissection, the blood is found accumulated in the veins and the right side of the heart; the arteries, brain, muscles, and all parts of the system are dark colored from the black blood contained in them; and the blood either remains liquid, or coagulates very imperfectly.

Dr. Southwood Smith, in describing this form of typhus, says, the patient "lies insensible, with a cold and dusky skin; with a swollen and livid countenance; with a heavy and oppressed respiration; with a pulse perhaps not to be felt, or, if distinguishable, either so rapid that it cannot be counted, so small that it is like a thread beneath the finger, and so weak that it is lost by the slightest pressure, or else slow, irregular, and intermittent. In this state the patient is almost as completely paralyzed as in apoplexy, and the attack is almost as rapidly fatal as apoplexy."—(*Treatise on Fever*, p. 175.)

The symptoms and post-obit appearances certainly are the same as those attending asphyxia produced by inhaling certain noxious gases, by mechanical obstruction of the lungs, and by a division of the respiratory nerves; and a careful consideration of the phenomena, I think, must lead to the conclusion that imperfect respiration is a most prominent feature of the disease. These circumstances surely demand a most careful attention to the disparity between the respiration and the pulse, which attends this form of disease.

Not only in typhus, but in all diseases, when the relative frequency of the respiration is less than in the proportion of 1 to $4\frac{1}{2}$, it is a sure indication of deficient aeration of the blood, unless, as in some rare cases, there is some disproportionate debility of the heart, occasioning frequent, feeble, and ineffectual contractions of that organ.

But there is, in many cases, deficient aeration, when the ratio between the frequency of the respiration and pulse is normal; and even when there is a comparative increased frequency of respiration. Typhous fever may be complicated with some affection of the bronchial membrane, preventing a free communication between the respired air and the blood within the lungs; or with some affection of the lungs or pleura, preventing a full expansion of the lungs; or with tympanitic distension of the abdomen (a common symptom in typhous and typhoid fevers), preventing a free descent of the diaphragm; or with other circumstances before adverted to as occasioning a mechanical impediment to the respiratory motions. Sometimes, also, in connection with the general debility attending typhoid diseases, there is a disproportionate debility of the respiratory muscles, causing the motions of respiration to be small, feeble, and inefficient. In all such cases the blood will be imperfectly aerated, unless the relative frequency of respiration is more than natural; as the deficient fullness of respiration ought to be compensated for by increased frequency. If the cause of this impeded respiration is manifest, it will of course be considered in counting the respiration and pulse; but if the impediment is latent, the relative frequency alone might lead to an erroneous conclusion. The degree of fullness of respiration is to be considered in connection with the frequency. Commonly, however, the imperfect aeration is sufficiently evident, from the livid tinge of skin, the drowsiness, listlessness, and other symptoms which it produces.

Pneumonitis.—In this disease, especially when of a typhoid character, the symptoms of imperfect aeration of the blood are always evident. In almost all cases the frequency of respiration is considerably increased. In a moderately severe case, with a pulse at 90,

the respiration will be as frequent as 30 in a minute—that is, in a ratio of 1 to 3; and when the lungs are extensively engorged, the ratio is often as 1 to 2. In one sense a very frequent respiration in this disease is a bad symptom, as it indicates extensive engorgement; but while the engorgement continues, this frequent respiration is favorable, and indeed absolutely necessary to sustain life. It is desirable that the increased frequency should compensate for the pulmonary obstruction; but it is rarely fully sufficient for this purpose. The “tumid, purple face or lips,” constituting a part of the definition of pneumonitis in Good and other authors, indicate that, notwithstanding the increased frequency of respiration, still the blood is imperfectly arterialized. A further increased frequency is desirable, provided there is not a corresponding increase of the pulmonary obstruction; if this obstruction is diminished, a proportionate diminished frequency of respiration is not unfavorable; but if the respiration suddenly becomes less frequent, while auscultation and percussion detect no abatement of the obstruction within the lungs, the symptom is alarming. It indicates that the nerves of respiration are losing their energy, and that imperfect aeration of the blood, with its consequences, muttering delirium, coma—in short, a fatal asphyxia—will ensue. The more typhoid is the character of the pneumonia, the greater is the danger of this failure of respiration. Indeed, in all typhous and typhoid diseases, a torpor of the respiratory nerves is to be apprehended as a common source of danger.

Typhous fever, complicated with pneumonitis, is a disease in which the effects of imperfect aeration of the blood are remarkably prominent. Dr. Southwood Smith, in treating of “typhus mitior with thoracic affection,” very well describes the ordinary phenomena of this disease. “Prominent thoracic affection, as we have seen,” he remarks, “is not infrequent in synochus; in typhus it is more constant; and the signs which denote its existence are more obvious, but they are not precisely the same. The pain in the chest is less severe; it is more often absent altogether; while the sense of stricture and the dyspnoea are more urgent. The cough is more constantly attended with mucous rattle; the respiration is shorter and more hurried. The skin in general is cooler, and it is always more dusky. The dark color of the skin, in severe cases becoming quite livid, is one of the most characteristic marks of intense thoracic affection. The color of the cheek is at first of a deep and vivid red; as the disease advances it becomes of a purple tinge, and at length it is quite livid. In these cases it is not uncommon for the respiration to be from forty to fifty in a minute. The pulse is invariably

rapid and weak.* The cerebral affection is equally peculiar and characteristic; it never consists of intense excitement; it is never accompanied with violent delirium; it is indicated by confusion and stupor passing rapidly into coma; and it is attended with low muttering incoherence or disjointed rambling, the trains of ideas that pass through the mind being extremely faint, and linked together by no distinguishable affinity. We know that one of the most essential conditions to the due exercise of the sensorial faculties is the due supply of the brain with arterial blood; but in this state of the system arterial blood does not and cannot circulate through the brain, because it is not formed in the lungs: the patient is in a state approaching to asphyxia, and in very severe cases he remains for several days in as perfect a state of asphyxia as seems to be compatible with life. Why debility should, in these cases, be carried to the utmost possible extent; why such cases should form the most exquisite specimens of the adynamic state, need not be pointed out: the disease is concentrated in the very organ which elaborates the pabulum of life, and that stream which should convey its vivifying and animating influence to every nook and point of the system, is corrupted at its source."—(*Treatise on Fever*, p. 169.)

With this clue to the prostrating influence of the black blood on the system, it is remarkable that Dr. Smith appears to have drawn no practical inference from it, even in the thoracic cases under consideration; and it is scarcely less remarkable that he should not have traced the effects of this influence in the other forms of typhus, and in other fevers. These effects of imperfect aeration of the blood are almost equally observable in the "typhus mitior with cerebral affection," and other forms of ever described by this author, and especially in typhus gravior.

The author also omits to mention the important fact that pneumonia, when occurring with typhus, is ordinarily of a *latent* character. Sometimes it manifests the thoracic symptoms which he has described; but more commonly not only the pain in the chest is "absent altogether," but no "sense of stricture" is complained of, there is no cough or expectoration, and, unless in the advanced stages, there is no "mucous rattle."

Another important omission in the detail of symptoms might seem remarkable, were it not common to most authors; in the description of one hundred and fifteen cases of fever, the number of respirations in a

* The *oppressed* pulse, which is common in this disease, is not "invariably rapid and weak," but sometimes infrequent, irregular and intermitting.

minute is stated in only two or three cases. That almost all authors neglect this point, while variations in the frequency of the pulse are carefully and minutely detailed, is sufficient evidence that the importance of the relative frequency of the respiration and the pulse has been most unaccountably overlooked.

Delirium tremens.—In this disease, according to my observations, there is always this imperfect respiration. Ordinarily there is a remarkable relative infrequency of respiration, even when the disease is complicated with affection of the lungs. Authors generally appear not to be aware how commonly this disease is thus complicated. In May, 1832, I lost a patient with delirium tremens, who had manifested few symptoms of pulmonary affection; but after death the lungs were found very extensively engorged. The case induced me to examine particularly for latent affection of the kind in all cases of this disease. Since that time, now six years, I have attended more than 60 cases, and have been surprised to find in every case decided indications of pulmonary engorgement. In most cases there is, in the early stages, a distinct crepitation, such as ordinarily attends pneumonitis; in other cases the sound is such as indicates edematous engorgement, resembling the sound produced by squeezing a wet sponge, by wringing wet clothes, or by the effervescence of fermenting liquors. The engorgement appears to be of a passive kind, being manifested in the most depending portions of the lungs—about the posterior portions, if the patient has been lying on the back; or in the inferior lobes, if he has been long in an erect posture. I am inclined to believe that this engorgement, which prevails through the whole course of the disease, has commonly been mistaken, in post-mortem examinations, for that passive accumulation in the back of the lungs which takes place in most diseases in the last moments of life, or after death. Since turning my attention to this point, my experience has coincided with that of the late Dr. David Hosack, of New York, who stated, in his lectures, that he had always found delirium tremens complicated with pulmonary disease.

As before remarked, the respiration is ordinarily infrequent. The ratio between the respiration and the pulse is sometimes 1 to 6 or 7, even when there is considerable pulmonary engorgement. This condition of the respiration accounts for the livid skin, and may be a principal cause of the cerebral perturbation and the trembling which characterize this disease.

Night-mare (*Ephialtes nocturnus*, Good) is unquestionably owing to imperfect respiration. This disease is described by Dr. Good, as

“produced during sleep, and interrupting it with violent struggle and tremor: the pressure on the chest seeming to be that of some hideous monster or phantom.” The respiration is remarkably infrequent, irregular, and interrupted; and commonly attended with a noise indicative of anxiety and distress. The mental hallucination is sometimes an apprehension of being crushed by some heavy weight, or of being violently grasped by some hideous animal, or of being smothered under a bed, or of being tightly bound or closely confined. In general, the hallucination is such as appears to have its origin in some interruption of the respiratory motions; and it is quickly dispelled by awaking, or by any external impression which excites the motions of respiration. It occurs during sleep, when respiration is deprived of the aid of the will; and is in many cases produced by a full meal taken at bed-time, which operates, in part at least, to impede the motions of the diaphragm. It most commonly occurs when a person is lying on the back, probably because in this position the weight of the lungs presses on the ganglia and trunks of the organic nerves, and the abdominal viscera crowd against the diaphragm, more than in other postures of the body.

B. Imperfect Aeration of the Blood from Disordered Function of the Organic Respiratory Nerves.

The aeration of the blood is immediately dependent upon the nerves distributed to the lungs from the *sympathetic, ganglionic or organic system*. The lungs may be sound and duly filled with air, but still the function of aeration is not performed without the aid of these nerves. A lesion of their function suspends the process of arterialization, notwithstanding the *motions* of respiration are continued, through the influence of the respiratory nerves.

Some degree of the imperfect action of these nerves is very common in *typhous and typhoid fevers* and other diseases, and especially in *erysipelas, scarlet fever, malignant cholera*, and some forms of *dyspnœa and asthma*. It causes the respiration to be frequent, irregular, sighing, and anxious. The patient, while possessed of consciousness, feels the unsatisfying effect of respiration, and often says that his breathing seems to do little good. All the voluntary muscles accessory to respiration are instinctively called into occasional vigorous action; but even after several successive full inspirations, a conscious want of further respiration remains. If this kind of breathing continues, in any aggravated degree, for a considerable length of time, it ordinarily becomes complicated with a torpor of the brain and respiratory nerves, and the patient sinks into a

state of asphyxia. This appears to be the most common fatal termination of scarlet fever, erysipelas and other similar diseases.

It is a fortunate provision of nature, that there is an intimate connection between this set of nerves, and the nerves governing the action of the heart ; in consequence of which there is *ordinarily* a relative proportion between the function of arterialization and the motions of the heart. If torpor affects the arterializing nerves of the lungs, it ordinarily affects, at the same time, the nerves of the heart. Hence, while the arterializing function is impaired, the heart sends a moderate quantity of blood to the lungs to be arterialized, the pulse becoming slow and infrequent, or frequent, small and feeble. In the course of typhus, and other fevers, the pulse sometimes becomes extremely infrequent—50, 40, and even 30 in the minute : in some cases this state of the pulse occurs at the onset of the fever.

This infrequent pulse may attend a torpor either of the motor respiratory nerves, or of the organic nerves of the lungs. In the former case, the breathing is infrequent, slow and small ; the skin livid ; and there is listlessness or tendency to coma. When the arterializing nerves are in fault, the skin is livid ; but the breathing is full, hurried, irregular, sighing and anxious ; and there is wakefulness, extreme mental anxiety, and sometimes delirium, succeeded by coma.

Cholera.—These circumstances are strikingly manifest in malignant cholera. In that disease the morbid cause seems to determine especially to the organic system of nerves. In some cases the process of arterialization seems at once almost wholly suspended—the peculiar sighing moan, and other symptoms of disordered respiration are observed, and the whole system assumes a livid hue. At the same time the pulse, at first feeble, soon ceases to beat. So far as the influence of the organic nerves extends, life is suspended ; while the energy of the brain and medulla oblongata, at least in some degree, remains. Consciousness, volition and respiratory motion continue ; but the arterializing function of the lungs and the motions of the heart have ceased. In this state I have seen a patient lie, perfectly pulseless, for more than eight hours, when the functions of organic life gradually revived, and the patient recovered.

Most physicians, like myself, from mistaken views of the pathology of this disease, treated their first cases by attempting to arouse the action of the heart with opium, alcohol and other stimulants. This attempt, in some cases, was too effectual. The heart being excited to action, the blood is thrown to the lungs, from which it returns not arterialized to the

heart ; the left ventricle now contracts, and sends the black blood, with its usual deadening influence, to the brain and whole system supplied by the arteries ; insensibility and coma ensue, and the patient dies asphyxied. Life may continue some time with a total stoppage of the circulation ; but it is soon extinguished by a circulation of black blood in the arteries.

The asthma with puerile respiration, described by Laennec, affords an example of this imperfect arterialization from disordered function of the organic nerves. " In cases of this kind," says Laennec, " the respiratory sound has resumed all the intensity which it possessed in early infancy ; we perceive distinctly the pulmonary expansion taking place with uniformity, completeness, and puerile promptitude, in all the air cells : and yet the patient is oppressed in his breathing, or, in other words, he constantly feels the want of a still more extensive respiration than he enjoys. The lungs, dilated as they are in an extraordinary manner for an adult, nevertheless have not capacity enough to satisfy the wants of the system. This affection is sufficiently common in persons affected with chronic mucous catarrhs, attended by a copious and easy expectoration. In such cases, the dyspnœa is frequently very intense, and is sometimes so aggravated by the slightest motion, that the patient, though otherwise in pretty good health, is condemned to a life of inactivity, or even to an almost complete state of immobility. Attacks of asthma, however, properly so called, are less frequent in such subjects, than in those affected with the dry catarrh. In these latter cases, the imperfection and small extent of the respiration easily account for the oppressed breathing. But in the others, even during the severest attacks, the completeness with which the respiration is performed is quite astonishing ; the sound of it is quite puerile ; and, as in the case of a strong and healthy child, we are sensible of the dilatation of the pulmonary cells to their full capacity, and over the whole extent of the chest. Nevertheless, the patient is oppressed, and, as I have already stated, would require a more extensive respiration than his organization allows ; in other words, the respiration is very perfect, but the wants of the system in relation to it are increased beyond the standard of health. In such cases it is not in the lungs that we must look for the cause of disease, but in the innervation or nervous influence itself ; and this will hold equally good, even if we adopt the chemical theory of respiration, and refer the dyspnœa to an extraordinary want of oxygen in the blood. If a temporary obstruction of the bronchia by a little mucus impedes the transmission of the air to even a small portion of the lungs, the patient experiences an extreme oppression."—(*Forbes's Laennec*, p. 412.)

SYMPATHY BETWEEN THE DIFFERENT NERVES CONCERNED IN RESPIRATION.

Such is the sympathy between the different nerves concerned in respiration, that there is rarely disordered function in one class of nerves, without some degree of similar disorder in the other class. In the diseases which have been adverted to, as examples of the disordered function of each class of nerves, commonly all of the nerves concerned in respiration are, in some degree, similarly affected. In typhous fever, for instance, the torpor of the motor respiratory nerves is commonly the more prominent, but there is ordinarily also some degree of torpor in the organic nerves; and in many cases it is not easy to decide whether one or the other class is the more affected. If disease commences with torpor of the organic nerves, the consequent imperfect aeration of the blood ordinarily soon occasions torpor of the motor nerves, by the paralyzing influence of the black blood.

Many diseases, besides those already adverted to, are commonly attended with deficient aeration of the blood. Dr. Stevens, for many years a distinguished practitioner in the West Indies, has particularly noticed the dark color of the blood in *yellow fever*, and some other diseases of tropical climates. Dr. Daniell has made similar observations in the *autumnal fevers* of Savannah. In *dyspepsia*, *hypochondria*, and some forms of *mania*, it may ordinarily be observed. From obvious causes it occurs in *croup*, and other diseases in which there is obstruction of the air passages. All fevers of a typhoid character are commonly attended with this condition of the blood; and indeed there are few diseases in which it may not occasionally occur.

From the preceding considerations it may be observed, that imperfect aeration of the blood is occasioned by various causes. Attentive observation of the symptoms in particular cases is requisite to ascertain whether there is any mechanical impediment to the expansion of the chest, or whether the fault is in the air passages, the lungs, the motor respiratory nerves, the respiratory muscles, or the organic nerves of respiration. A correct diagnosis in regard to these circumstances is highly important in a therapeutic point of view.

THERAPEUTIC INDICATIONS.

It is doubtful whether, in any disease, an *excessively aerated condition of the blood* is a prominent morbid feature. I suspect that such a condition sometimes occurs, dependent upon irritative excitement of the organic nerves, in erysipelas, scarlet fever, and some other diseases; but,

if so, this state ordinarily is soon followed by collapse, with imperfect arterialization. On the contrary, there are few diseases in which *deficient arterialization* does not sometimes occur. Bichat considered it as by far the most common immediate precursor and cause of death ; and I think it has been rendered evident, in the preceding part of this essay, that such a condition of the blood has some degree of injurious influence, in various stages, and sometimes throughout the progress, of many diseases.

The general therapeutic indication, therefore, connected with the relation between the respiratory and circulating functions, is *to promote the arterialization of the blood*, or, in other words, *to remedy deficient respiration*.

Contra-indications in cases of deficient respiration.

Stimulants, which ordinarily operate to increase the action of the heart, without a corresponding increase of the respiration, should be withheld, or given with extreme caution, when the blood is imperfectly arterialized. From erroneous pathological views, much injury is done, in such cases, with this class of remedies. The deleterious effects of such medication in cholera have been already adverted to ; and the same remarks are applicable to cases generally in which the respiration is in a diminished proportion to the pulse. The paralyzing influence of the imperfectly aerated blood occasions a torpor of the whole system. The heart becomes affected with this torpor, and the feeble, small, and sometimes slow, infrequent pulse seems to indicate debility of this organ. It is, however, commonly a torpor or oppression, rather than the debility of exhaustion ; the respiration is inadequate to produce that change in the blood which renders it fit fully to support the vitality of the organs to which it circulates ; there is already more blood circulating through the lungs than they can arterialize. Under these circumstances, *alcohol* and *fermented liquors*, *opium*, *quinine*, *serpentaria*, and all articles which operate to increase the action of the heart, more than that of the lungs, may have a most injurious effect. By transmitting an additional quantity of blood to the already over-burdened lungs, they cause the whole mass of blood in the system to become more deteriorated, and thus add to the torpor which occasions the apparent debility. Such effects are too frequently produced in the progress of typhous fever, typhoid pneumonitis, and other diseases, especially in the last moments of life.

We will suppose a case of *pneumonitis*, in which during the progress of the disease one half of the lungs has been obstructed by engorge-

ment. The pulse has been about 90, the respiration 35 or 40. The respiration has been thus frequent, because one half of the lungs has had to perform the whole office of arterialization; yet the tumid, purple lips, the general lividity of skin, and some cerebral oppression, have shown that, with this forced effort, the respiration still has been deficient. At length—commonly on the sixth day—there is an effort towards a crisis. There is as yet little if any resolution of the engorgement within the lungs; but there is increased secretion from the bronchial membrane, while the secretions of the system generally are beginning to be unlocked. The lungs, almost suffocated by the bloody mucus poured out into the bronchia, are struggling with increased effort to perform their office. All the accessory, as well as ordinary muscles of respiration, are engaged in agonizing labor to aerate the blood. But the lividity of skin has increased, and the brain, rendered torpid by the black blood circulating in its arteries, scarcely allows the aid of the will to sustain the respiratory efforts. Under these circumstances active stimulants are administered for the purpose of supporting the sinking powers of life. The action of the heart is excited, and the blood is hurried through the lungs, at once overwhelming the exhausted respiratory powers. For a few moments the system appears to make a renewed struggle to relieve itself of the suffocating oppression; but coma comes on; the respiration, becoming feebler and shorter, soon stops; and the heart, “the ultimum moriens,” after a few more feeble, irregular pulsations, yields under the deadening influence of the black blood.

Cases of the above description are not uncommon; and a less degree of the injurious effects of such stimulants, given in the progress of fevers attended with deficient respiration, it is believed, is one of the most common errors of medical practice.

Yet there are cases of deficient respiration—cases attended with absolute debility or atony—which are benefited by these remedies. Coma even sometimes is relieved by full doses of opium; and in small doses opium and other stimulants often may be serviceable in absolutely atonic cases. Their operation, however, should be carefully watched; and if they increase the action of the heart, without a corresponding increase of the respiratory function, the operation will be injurious.

A *nutritious diet*, by invigorating the circulation, and increasing the quantity of blood; and *muscular exercise*, by hurrying the circulation, commonly have an injurious effect, in cases of this comparative infrequency of respiration.

This disparity between the respiration and pulse is aggravated also

by remedies which operate directly to diminish the frequency of respiration. Most of the *narcotics*, given in full doses, so as to affect the brain, producing vertigo, drowsiness, or coma, have this effect by inducing torpor of the brain and respiratory nerves; and some of them in moderate doses have a similar operation.

Strychnine in large doses occasions the respiration to be remarkably slow, irregular and infrequent; while in moderate doses it sometimes improves the respiratory function. I am now treating a gentleman for paralysis of the portio dura with this remedy, in whom one sixth of a grain four times a day produces formication, slight pricking pains, and frequent spasmodic twitching of the muscles. While under this operation, the ratio between the respiration and pulse is about 1 to 7 or 8; though the patient has the ordinary healthy ratio, 1 to $4\frac{1}{2}$, when not under the influence of medicine. In this case, however, the strychnine does not appear to occasion a deterioration of the blood proportionate to the diminished frequency of respiration; and in less doses it is a useful remedy for deficient arterialization depending on a torpor of the organic nerves. In such cases it appears to have an exciting operation on the arterializing nerves, as might be inferred from its efficacy in some forms of asthma and dyspnœa, in which a torpor of these nerves is manifested.

By a similar operation, as before remarked, alcohol, opium, and the exciting narcotics generally, in small doses, sometimes have a favorable effect. Their general exciting operation may be determined especially to the organic nerves of the lungs, or to the brain and motor respiratory nerves, occasioning the breathing to be more full and easy, and the blood to be more perfectly aerated. In some epidemics these effects are so uniform that the physician learns to prescribe such remedies in particular cases, with almost perfect confidence. Aside from the observation of epidemic peculiarities, however, and a consideration of the attending general debility, I know not what general rules can be given to enable a practitioner to calculate on a favorable operation of such remedies, in cases of imperfect arterialization of the blood. As before observed, when used in such cases their operation should be carefully watched; and if they are found to excite the circulatory, more than the respiratory function, their operation will be injurious.

Remedies which promote the arterialization of the blood.

These are,

1st. Remedies which diminish the action of the heart and arteries.

2d. Remedies which excite and invigorate the motor respiratory nerves.

3d. Remedies which excite and invigorate the arterializing nerves of the lungs.

4th. Ventilation.

5th. Remedies which obviate mechanical impediment to the respiration.

6th. Remedies which excite secretions vicarious of respiration.

1st. *Remedies which diminish the action of the heart and arteries.*

These remedies obviate a disparity between the two functions by reducing the circulation to a proportion with the respiration. The *anti-phlogistic* medicines generally belong to this class.

Venesection is one of the most important of this class of remedies. If the pulse is frequent, full and strong, with a comparative infrequency of the respiration; or, as occurs in pneumonitis, pleuritis, bronchitis, and some other diseases, if, with this condition of the pulse, the respiration is frequent, but still inadequate to a due aeration of the blood, there can be no question as to the propriety of bleeding to reduce the circulation. There are other cases, equally requiring bleeding, in which the indications are less obvious. Imperfect respiration, by producing torpor of the heart and arteries, through the ordinary influence of the black blood, may render the pulse infrequent, slow and feeble. This constitutes what is called the *oppressed, depressed, or obstructed pulse*.

This oppressed pulse is common in the congestive variety of typhous fever, in some forms of pneumonitis, and in other diseases. When a vein is opened, the blood runs slowly, and has almost a tarry consistence and color; but as the circulation becomes relieved, and the process of aeration is better performed, the blood assumes a florid appearance, and runs freely. This change in the blood takes place more suddenly when some degree of fainting occurs during bleeding, to check or suspend the heart's action; hence when the principal object of bleeding is to restore the balance between the respiration and the pulse, and promote the aeration of the blood, it is well to encourage fainting by bleeding in an erect posture.

The oppressed pulse may occur in a highly inflammatory, or a low typhous or typhoid condition of the system. In both these conditions, bleeding tends to restore the balance between the respiration and the pulse. In the former, bleeding is required not only to reduce the pulse to a proportion with the respiration, but also to subdue inflammation—the pulse rises in fullness and strength, as the oppressing effects of the black blood are removed; and the bleeding may be continued freely. In a low typhoid case, only one of these objects is to be accomplished

by bleeding, which should be stopped as soon as faintness is induced, or the blood assumes a florid, arterialized appearance ; or, if possible, the disparity between the respiration and the pulse should be obviated by other means without bleeding.

Antimony has a striking effect in diminishing the action of the heart, without producing a corresponding diminution of the respiration. In cases of inflammatory excitement it is useful in reducing arterial action, but it is particularly useful when such excitement is connected with deficient respiration.

This affords one reason for its efficacy in pneumonitis, in which this remedy has been employed successfully in frequent large doses, by Rasi, Laennec, and other modern writers. In this disease, the refrigerant and alterative powers of the remedy have a favorable operation, in reducing and resolving inflammation ; but I have found it especially adapted to those cases in which the symptoms of deficient arterialization are prominent—when the respiration is infrequent and small, the skin livid, and the cerebral powers oppressed. Laennec observed patients, in this disease, to recover their consciousness under the use of this remedy ; and he advises a persevering employment of it when “the oppression is great, or the head affected.”

Dr. Thomas Marryatt, of Bristol, England, who published a treatise on therapeutics, in 1788, gave tartar emetic successfully in fever and in pleurisy. “I have seen many instances,” he observed, “wherein a paper has been given every three hours [gr. x. in six papers], without the least sensible operation, either by sickness, stool, sweat, or urine ; and, though the patients had been unremittingly delirious for more than a week, with subsultus tendinum, and all the appearances of hastening death, they have perfectly recovered without any other medical aid—a clyster every other day excepted.”

Laennec found tartar emetic successful in “hydrocephalus” [cerebral congestion ?], supervening “in the course of continued fever,” and “general debility”—also “in nervous affections connected with a congested state of the brain or spinal marrow.”

Dr. Graves employs this remedy in delirium tremens, and “with very remarkable success at various periods of fever, but principally towards its termination.” In the low stages of spotted fever, when the symptoms denoted “a combination of primary general nervous excitement with a secondary cerebral congestion,” he found a combination of tartar emetic with laudanum very successful. “This method,” he observes,

“has manifestly saved many, many lives, under a combination of circumstances apparently hopeless.”—(*Graves's Clinical Lectures.*)

In the low stages of many febrile diseases, opium may be given advantageously in combination with antimony, when it could not be given alone, without danger of producing cerebral congestion. The opium allays nervous irritation, exercises its general stimulant operation, and thus sustains the powers of life ; while the antimony, by preserving the balance between the respiratory and circulating functions, and thus promoting the arterialization of the blood, prevents the congesting effects of the opium.

Ipecac, like antimony, operates to diminish the force and frequency of the heart's action, and thus obviates a disparity between the respiratory and circulating functions. It is less powerful than antimony ; but is appropriate to some cases, in which the more debilitating effects of antimony might be injurious.

The *refrigerant salts*, nitrate of potassa, bitartrate of potassa, sulphate of magnesia, sulphate of soda, &c., reduce the circulation, and in appropriate cases thus have a favorable effect in equalizing the respiratory and circulating functions.

In the use of antiphlogistic remedies, for the purpose under consideration, the *general tone of the system* is to be observed ; and in low atonic cases caution is required, lest their general debilitating effects shall more than counterbalance the advantage of equalizing the respiratory and circulating functions. In low stages of typhous fever, for instance, these remedies sometimes may be required for this purpose ; but as it is important, in such cases, to avoid the occasion of debility and exhaustion, it is desirable to equalize the functions by other means ; and when debilitating antiphlogistics are employed, their operation should be continued no longer than necessity requires.

Digitalis is well known to possess the property of diminishing the frequency and force of the pulse in a remarkable degree. It sometimes has a similar effect on the respiration, especially in large doses, but not in proportion to its effect on the pulse. By virtue of this operation, it is often useful in typhus, pneumonitis, erysipelas, scarlet fever, and other diseases, and particularly in congestive fevers. It relieves morbid wakefulness, subsultus tendinum, muttering delirium and coma ; and sleep induced by it is commonly more refreshing than when induced by opium and most other narcotics, because the respiration is less oppressed.

In a former part of this essay, the remarkable deficiency of respiration which occurs in *delirium tremens* has been noticed ; and the success

with which I have treated this disease, principally with digitalis, induces me briefly to describe my general plan of treatment. In 1820, Dr. A. L. Peirson, of Salem, Mass. (New Eng. Jour. of Med. and Surg., Vol. IX.), recommended digitalis in the treatment of this disease. After bleeding, he gave the tincture, in doses of seventy-five drops, every two hours.

Several years since, owing to epidemic constitutional changes, or some other reason, I observed that opium was less successful in this disease, than it had formerly been in my practice; and I was induced to make trial of the digitalis. I commence the treatment of a case with a full cathartic dose of calomel, which is followed with the exhibition of nitrate of silver,* in doses of gr. 1-8, every hour, or gr. 1-4 every two hours. If called in the early part of the day, I adopt no direct means for inducing sleep until night—the natural time for sleep. In the evening I direct one ounce of tincture of digitalis, of which a third part is to be given every two hours until sleep is induced. If this fails, the nitrate of silver is resumed and continued through the following day; and on the following night an ounce and a half of the digitalis is directed, one third to be given every two hours. In a great proportion of cases sleep is induced, and the disease suspended, the first night; and it is very rare that the wakefulness continues through two nights. In most cases no other remedies are used; though sometimes, in connection with them, I direct castor, artificial musk, camphor, or some bitter infusion, with a blister to the back of the neck, or a wash of tincture of cantharis and aqua ammoniæ to the scalp. In a few cases the digitalis has been rejected from the stomach, when I have directed smaller doses at shorter intervals. Of more than 50 cases, treated on this general plan, only four have been fatal. One had been tampered with by a quack, before I was called; the second was complicated with a severe pneumonitis affecting both lungs; the third came on in the course of a severe dysentery—sleep was induced, but the patient sank, after two weeks, with the dysenteric symptoms; the fourth was complicated with erysipelas affecting the face and head, and terminated fatally on the ninth day. In the latter three cases, death appeared to be owing less to the delirium tremens, than to the diseases with which it was complicated.

Ergot has even greater efficacy than digitalis in depressing the circulation. In doses not sufficient to produce any violent effects, it will reduce the healthy pulse from 70 to 50 or even 40 in a minute. But at the

* For a notice of the medicinal properties of this remedy, see subsequent part of this essay.

same time it depresses the respiration. While digitalis affects the motor nerves of the heart more than it does the respiratory nerves, ergot affects both, and in most cases the respiratory nerves chiefly. When the object is simply to diminish the action of the heart, as in active and irritative hemorrhages, I have found this remedy incomparably more valuable than any other; but on account of its depressing the respiratory motions, it is decidedly injurious in cases of deficient arterialization; and it is noticed, in this place, only to contrast its powers with those of digitalis.

Sanguinaria Canadensis in its medicinal effects is considerably allied to digitalis. It is narcotic and alterative. By its narcotic operation it diminishes the frequency and force of the heart's action; and by virtue of this operation, when the circulation is proportionately more active than the respiration, it restores an equilibrium of action. It is particularly useful in diseases of the lungs and bronchial membrane. In pneumonia, catarrh, croup, and other diseases of the respiratory organs, its alterative operation promotes healthy secretion, produces resolution, and thus aids the respiratory function, by improving the condition of the lungs, while its narcotic operation tends still further to equalize the respiratory and circulating functions by depressing the action of the heart. In such cases, when the skin is livid, the cerebral powers are oppressed, and other symptoms of imperfect arterialization are manifest, its favorable operation relieves the cerebral symptoms, and gives a florid hue to the skin. As an operation consequent to these effects, the *oppressed pulse*, which is common in such cases, often becomes more frequent, full and strong—an effect, which probably has occasioned the common, but erroneous opinion, that sanguinaria operates directly to stimulate the action of the heart.

In very large doses, sanguinaria, like most other narcotics, produces torpor of the brain and respiratory nerves, with infrequent, slow, and stertorous breathing, and its consequences, the ordinary symptoms of asphyxia.

Colchicum, *Veratrum*, *Nicotiana tabacum*, and *Lobelia inflata*, with general narcotic and alterative powers like sanguinaria, have also a similar operation in diminishing the action of the heart.

Polygala Senega, though destitute of narcotic powers, is similar to sanguinaria in its alterative effects, and in its operation on the heart. The latter operation, probably, is dependent on the *nauseating property* of the remedy—a property which, in several of the articles before enumerated, contributes to diminish the action of the heart.

2d. *Remedies which excite and invigorate the motor respiratory nerves.*

Articles generally which produce sudden cerebral excitement with mental exhilaration have this effect. *Ether, camphor, ammonia, musk, castor, assafetida, oil of amber, cajuput oil*, and the volatile terebinthines, such as *oil of turpentine* and that of the *Abies Canadensis*, belong to this class. These remedies are commonly termed *diffusible stimulants*; but, with the exception of the volatile terebinthines, they have little, if any, direct stimulant operation on the heart. Their main operation is on the nervous system. They produce *cerebral excitement*, relieving drowsiness, coma, and low delirium, and in virtue of this operation they call the *aid of the will* to assist in respiratory action; and at the same time they appear to have a direct *exciting operation on the respiratory nerves*. In the low stages of typhous and typhoid fevers, when the respiration and the cerebral functions are oppressed, they quicken the respiration, and thus tend to relieve coma, delirium, subsultus tendinum, and other symptoms of nervous oppression. They are especially useful about the time of the crisis of fevers, particularly the crisis of pneumonitis and other diseases of the respiratory organs. Their operation is ordinarily transient; but the frequent use of these various articles, in succession, is highly important in sustaining the nervous energy and the respiratory action, through the critical period of such diseases. Whenever in the progress of typhous or typhoid fevers, the respiration is observed suddenly to become infrequent, these remedies should be promptly and perseveringly employed to quicken the respiration and prevent the deadening influence of the black blood through the system.

Dr. Graves highly recommends this class of remedies, in cases "when there is great prostration of the powers of life, oppression of the nervous functions, and low, muttering delirium;" and a remark of his in regard to musk, that "it exercises a stimulant effect on the nervous system, without having any tendency to produce cerebral congestion or coma," is applicable, in general, to other remedies of this class. Indeed, the practice of giving these remedies, for the relief of such symptoms, is common; but the rationale of the practice, and the leading principle, that coma and other symptoms of cerebral oppression are commonly owing to imperfect respiration, have not been generally understood.

Enemata of some of the articles above enumerated—particularly of camphor and oil of turpentine—sometimes operate very promptly to relieve oppression of the respiratory and cerebral functions.

Coffee and green tea are mild but valuable remedies of this class. I think that injury is often done to persons who habitually use these articles in health, by withholding them during sickness. In typhous fever, typhoid pneumonitis, and many other diseases, their remedial efficacy, in producing cerebral excitement, and in quickening the respiration, is important. The use of strong tea, in cases of stupor occasioned by excessive doses of opium or alcohol, is common.

External vesicatories and irritants, such as cantharis, nitrate of silver, corrosive sublimate, mustard, oil of turpentine, oil of cinnamon, and the like, are valuable adjuvants in such cases. A blister applied to the back of the neck is one of the most common remedies for coma and other symptoms of cerebral oppression; and probably irritants applied to this region, from its proximity to the origin of the respiratory nerves, are more effectual than to other parts of the system. Dr. Graves prescribes blisters with this view; and in some cases of typhus, I think I have seen good effects from continuous irritation in this region, excited by a pitch plaster, with a small quantity of pulverized nitrate of silver sprinkled on its surface.

Calling the attention of a patient to his respiration, and prompting him to take frequent full inspirations, tend to keep up the process of aeration, and to prevent the patient from sinking into a comatose condition. I am always careful, about the sixth day of pneumonitis, to watch the symptoms of an approaching crisis. If the symptoms of deficient arterialization are increasing, as always occurs when the crisis is likely to prove serious, I perseveringly employ the diffusible excitants above mentioned, apply a blister or other irritant to the back of the neck, and whenever the respiration flags I arouse the patient to the necessity of full and frequent inspirations. I remain by the patient, until a nurse or other attendant has learned this mode of management, which in some cases is required to be continued for several hours. By this management I have seen patients sustained through the critical period of this disease, who otherwise would almost certainly have sunk into a fatal asphyxia.

It is well known, that in a low typhous or typhoid state, it is necessary that a patient, who inclines to sleep, should be frequently aroused. In natural healthy sleep the respiration is ordinarily slower and less frequent than during wakefulness. The ratio between the respiration and the pulse ordinarily becomes 1 to 5 or $5\frac{1}{2}$. The aid of the will is withdrawn, and the breathing is performed wholly by the involuntary respiratory nerves. In low typhous fevers the disparity during sleep becomes

still greater. While awake a patient feels those distressing sensations, which attend imperfect aeration of the blood, and which instinctively demand the aid of the will to assist the torpid and enfeebled respiratory nerves and muscles ; but during sleep, the aid of the will being withdrawn, the breathing becomes irregular, intermitting, short, and infrequent—a breathing which in this diseased condition would soon overwhelm the system with asphyxia.

But in spite of all our efforts, the respiration sometimes flags, and patients sink into a comatose sleep, from which, for a time, they cannot be fully awaked. Our efforts should be still continued ; if the patient is able to swallow, the most diffusible excitants, ammonia, ether, camphor, &c., should be administered little diluted, so as to make a strong impression on the mouth and fauces ; or the same substances should be applied to the nostrils, or sprinkled on the face. These means, with perhaps the aid of frictions over the chest, if they do not awake the patient, will generally arouse the system enough to occasion several successive full inspirations. I recently saw a little patient recover from a coma succeeding scarlet fever, during which, for about three days, the breathing absolutely stopped, whenever these means were discontinued even for a few minutes.

In a similar way cases of profound coma consequent to large doses of opium and other narcotics, taken by accident or with suicidal purposes, have been treated successfully by *flagellation* and other violent *external irritation*. That such means prove efficacious by exciting and sustaining the respiration, may be inferred from experiments, made by Brodie and others, of supporting life, under the influence of enormous doses of certain narcotics, by artificial respiration. These experiments prove that such narcotics occasion death by suspending the respiratory motions and inducing asphyxia, rather than by a direct operation on the brain.

This general mode of treatment has been applied to extreme cases of intoxication with remarkable efficacy.

3d. Remedies which excite and invigorate the arterializing nerves of the lungs.

Most of the remedies above enumerated, which operate to excite and invigorate the motor respiratory nerves, have in some degree a similar operation on the organic nerves of the lungs. Such is the sympathy between these two classes of nerves, that when one of them is affected with torpor, the other is in some degree similarly affected ; and the remedies which affect one class, also ordinarily affect the other. But

the effects of artificial respiration in cases of coma caused by alcohol, opium, and other stupifying narcotics, show that in these cases the torpor is principally in the brain and motor respiratory nerves. On the other hand nervous asthma, malignant cholera, and some other diseases, are instances in which the torpor is chiefly in the organic nerves, while the brain and respiratory nerves are comparatively little affected.

These circumstances afford grounds for a distinction of two classes of remedies. The class above treated of operates principally on the motor respiratory nerves. The remedies next to be considered appear to operate principally on the organic nerves, though some of them have also an evident operation on the motor nerves. In general this class produces a gradual and permanent increase of nervous energy, while the former class effects a sudden and more transient excitation.

Nitrate of silver, arsenical solution, chlorine, cantharis and capsicum, are the principal remedies of this class. Tetrakinitrate of bismuth, sulphate of zinc, and bisulphate of copper, have a less degree of the same operation. Mustard, and other pungent tetradynamous plants, also belong to this class.

Nitrate of silver.—I consider this article as one of the most valuable remedies for restoring and sustaining the balance between the respiratory and circulating functions. It commonly increases the frequency of the respiration ; but it appears to operate more on the organic nerves.

My common dose is gr. 1-8, in pill, repeated every hour, or once in two or three hours, according to the urgency of symptoms. Frequently I give a solution of the following form : R. Nitrat. argent. gr. ij. ; aquæ distillat. 3j.—dissolve and add syr. simp. 3vii. M. The dose of the solution may be such as to contain from 1-8 to 1-4 of a grain. The solution is the preferable form when an effect of the remedy on the fauces is desirable, as in scarlet fever, and some other diseases ; and it is ordinarily more easily administered to children than the pill.

In typhous and typhoid fevers, in which a failure of the respiration is a source of no inconsiderable part of the danger to be apprehended, I place much reliance on this remedy. *Infrequent respiration, abdominal tympanites,* aphtha, subsultus tendinum, and coma*—symptoms which are commonly associated in typhus—are some of the most prominent particular indications for its exhibition. Commonly, however, I commence its use as soon as any degree of deficient respiration is observed, and continue it through the whole course of the disease. When there

* For my first hint in regard to the efficacy of nitrate of silver in obviating tympanites, I am indebted to Dr. Lester Keep, of Fair Haven, in this county.

is a great degree of deficient respiration, and the disease has decidedly the congestive form, with urgent symptoms of oppression of the respiratory and cerebral functions, bleeding, antimony, the diffusible excitants, or other remedies, which more promptly relieve such symptoms, are required ; but to prevent these symptoms, to relieve them when moderate in degree, and to sustain the respiratory function when restored from a state of depression, I have found no remedy more efficacious than nitrate of silver. The intestinal hemorrhage, which often occurs in the course of typhus, I have almost invariably observed associated with tympanites ; and with the subsidence of the tympanites, which this remedy is almost sure to effect, the hemorrhage has always ceased.*

In delirium tremens this remedy contributes to obviate the imperfect respiration, which has been noticed in this essay, pages 21 and 31, as a prominent symptom of the disease. It relieves also the tremor, false vision, and other symptoms of nervous disorder. These effects are sometimes so obvious to attendants, when the remedy is alternately administered and withheld, that I have been often asked whether its design was to obviate the trembling.

In the treatment of typhoid pneumonitis I consider this remedy a valuable adjuvant, and in many cases I employ it through the whole course of the disease.

In phthisis the nitrate of silver has been highly recommended ; but physicians generally appear to have been disappointed in the use of it. As a curative remedy, in this disease, little can be expected from it ; though it is useful in relieving occasional symptoms, as paroxysms of dyspnœa, and the drowsiness, livid skin, and other symptoms denoting imperfect arterialization of the blood, which frequently occur.

Dyspnœa, asthma, dyspepsia, hypochondrias and cholera infantum, are diseases to which this remedy is often adapted ; and in most diseases attended with general nervous torpor or irritability, or with flatulent distension of the intestinal canal, or with any of the symptoms above mentioned, as constituting particular indications for its exhibition in typhous fever, the nitrate of silver may be advantageously employed.

* In the use of nitrate of silver, the greatest caution is requisite in regard to chemically incompatible remedies. Most authors complain of the uncertain operation of this remedy ; and I am confident that inattention to this circumstance is a common cause of the failure of its efficacy. It is ordinarily inert, if given in connection with any alkali or alkaline salt. Ammonia or prepared chalk, for instance, wholly neutralizes its power ; and the alkaline salt contained in Dover's powder frequently has this effect. A practitioner, who was formerly a student of mine, several years since complained to me that he had been often disappointed with nitrate of silver in treating typhus. On inquiry it appeared that, in connection with this remedy, he frequently prescribed a mixture containing carbonate of ammonia. Since that time he informs me that he prescribes the remedy with the greatest confidence, and that he could hardly dispense with it in the treatment of typhus.

The following case of *erythema anatomicum*—a case of the writer's personal experience—may serve to show the general indications for which I prescribe the nitrate of silver in erysipelas, scarlet fever, and other allied diseases, as well as to illustrate some other points connected with the general subject of this essay.

One afternoon in March, 1834, I examined the body of a man who died the day previous with a malignant erysipelas affecting the face, scalp and brain. I had at the time on my left thumb two slight scratches made with a common pin a few hours previous; and while examining the body I slightly scratched the same thumb with the point of a scalpel. They were slight abrasions of the cuticle, not sufficient to occasion the least oozing of blood. On the following morning these scratches were a little red and inflamed, attended with a slight itching and smarting sensation. I touched the thumb with a piece of nitrate of silver; and, without apprehension of danger, proceeded to visit my patients during the forenoon. At 11 o'clock, A. M., about twenty hours subsequent to the post-obit examination, I was seized with chills, which continued violent about an hour, when heat of skin, thirst, a quick, frequent, jerking pulse, and other symptoms of irritation and febrile excitement supervened, with nausea and vomiting. There was now no irritation about the thumb, nor any inflammation extending up the arm; and the slight injury of the thumb did not even occur to my mind as the cause of the present symptoms. An emetic of ipecac, with a small proportion of tartar emetic, produced no relief. At evening a swelling and soreness of a gland in the axilla was noticed; and in the course of the night a vivid erythematic inflammation covered the whole left side of the chest. From this time symptoms continued severe, and with little variation until the eighth day of the disease. The pulse was ordinarily from 120 to 130, quick and jerking, but weak; skin rather hot and dry; the affected side painful, and so sore that friction of the bed-clothes or any slight touch seemed intolerable. But the prominent symptom, indicated by my feelings, was a difficulty of respiration, evidently connected with affection of the organic nerves. I frequently observed to my attending physicians, that my respiration seemed to be scarcely of any service; and that the sensation was as though the breath was drawn into an inanimate bag. During occasional mental aberration I fancied that I was using a pair of borrowed lungs. The acute pain and soreness attending the disease seemed trifling as compared with this distressing suffocating sensation. For eight days and nights I was not conscious of a moment's sleep; and when I shut my eyes they

were filled with as many imaginary objects, as ever haunt the mind of a patient with delirium tremens. The general nervous irritation, the sensation of impending suffocation, and the want of sleep, were truly agonizing. The disordered function affected the motor, as well as the organic respiratory nerves ; and a constant effort of the will was required to sustain the motions of respiration. With such continued effort I ordinarily made from 25 to 35 inspirations in a minute ; but still the respiration was unsatisfying. During this period the nitrate of silver, in doses of one eighth or one fourth of a grain, every two or three hours, and sometimes every hour, was almost constantly employed. It rendered the respiration easier, and mitigated the general constitutional irritation ; and whenever its administration was suspended for a few hours, the distress and anxiety of breathing became extreme. No other internal remedy showed decided beneficial effects. All exciting remedies appeared to fall in with the diseased irritation and aggravate it. A few drops of laudanum, or a teaspoonful of brandy, produced a distressing nervous excitement through the whole system. Two drops of the oil of valerian seemed to pervade the system with a thrilling sensation, almost like electricity, increasing threefold the nervous irritation. After the disease had progressed several days, the local affection was treated with a wash of the nitrate of silver, 48 grains to 3ij. of water, so as to vesicate almost the whole left side of the chest, with a most happy effect on the local and constitutional symptoms.

I expected this state of irritation to be followed by a general nervous torpor, and apprehended danger from failure of the respiration. I directed the attention of the nurse to this subject ; and told her what symptoms would require notice, and what remedies would be needed, should my consciousness and respiration begin to fail. On the eighth day the nurse observed me suddenly fallen into a state of drowsiness, with shortness and extreme infrequency of respiration. On being aroused I found a torpor pervading the system ; the whole lower extremities were entirely devoid of feeling ; and though the sun was shining bright against my windows, a sense of darkness rendered surrounding objects scarcely visible. My attentive and judicious nurse prompted me to vigorous respiratory efforts ; but such was the mental and physical torpor that respiration could hardly be continued. The skin at this time, as I was subsequently informed, assumed a deep livid hue ; and, notwithstanding the assiduous exertions of attendants, my respiration occasionally sunk to *ten* and even *eight* in a minute, while the pulse was beating irregularly about 130. Ether, ammonia and camphor

were freely administered, and applied to the nostrils; and frictions with volatile liniment and oil of cinnamon were perseveringly employed. I soon revived in some degree; but for several hours the sense of darkness induced me to suppose it real night; and respiration was sustained only by constant and laborious efforts. The involuntary respiratory nerves seemed almost powerless; and for more than twenty-four hours I could not be suffered to sleep longer than two or three minutes, without a nearly total cessation of breathing. The sensations at this time were very different from those of the preceding days, when the difficulty of respiration seemed chiefly depending on the organic nerves. Then the breathing was anxious—the conscious feeling of imperfect respiration, with the exercise of reason, called for vigorous and hurried respiratory action. Now consciousness, sensation, reason and muscular energy were at the lowest ebb; the little life which remained was a burden; and the exertions of friends to arouse me seemed an annoyance. A person who has never experienced the feelings attending such a state can have no adequate idea of them. As consciousness and reason revived, I felt like one who is laboring to escape from drowning; who has been swimming for the shore, until his strength is almost exhausted; occasionally his head is suffered to sink in despair, and again the agonizing sense of suffocation calls for another desperate struggle; while every wave threatens to overwhelm the last effort of exhausted nature.

After this critical period, wine, brandy, quinine, and a moderate use of opium, operated favorably. Two abscesses formed on the posterior part of the side, each of which discharged five or six ounces of healthy pus.* I was confined to the room in all five weeks. Much of the time there was considerable tendency to tympanitic distension of the abdomen, which was promptly relieved by more full and frequent doses of the nitrate of silver. The disordered function of the nerves concerned in respiration, which was so remarkable through the whole disease, continued in some degree even after I was able to resume the active duties of my profession. Frequently I was aroused from sleep by a sudden deep spasmodic sighing inspiration, which sometimes also affected me when awake.†

* Dr. Higginbottom speaks highly of the external use of nitrate of silver in promoting healthy suppuration. I have observed many proofs of the correctness of his views; and I am fully satisfied that the internal use of the remedy has a no less salutary effect in promoting this object.

† A remarkable symptom, attending the early stage of my disease, was a morbid excitation of the faculty of memory. Articles that I had read cursorily, years before, were fresh in memory, so that I could recollect not only general ideas, but almost the precise language, pages, &c., points on which my memory ordinarily is very deficient. After the critical stage of collapse, there was a propor-

Arsenical solution.—It has been a matter of dispute whether this article is a stimulant to the circulating system. I am undecided whether it is directly so, or only secondarily through the influence of the arterializing function. The latter operation is certainly the most prominent; and it is therefore a valuable remedy in the congestive form of typhous and typhoid fevers. Drs. Miner and Tully recommend this article as a valuable remedy in the low stages of typhous and other fevers, when the general debility is attended either with irritability or torpor.—(*Essays on Fevers.*)

Cantharis, as an internal remedy, is of much value in the low torpid stages of typhous and typhoid fevers, particularly those of a congestive form, in which the respiratory function is deficient. It operates upon the nervous system generally, relieving subsultus tendinum, coma, and other symptoms of nervous exhaustion; and its effect on the nerves concerned in respiration, I think, constitutes no inconsiderable part of its favorable operation.

Capicum is particularly adapted to scarlet fever and erysipelatous diseases generally; but is useful in the low stages of most diseases attended with nervous torpor.

Chlorine.—The change which this remedy effects in the blood has been noticed by several writers, and different views have been entertained in regard to its *modus operandi*. It is useful in typhus; but more especially, I think, in scarlet fever and erysipelatous diseases. The chlorides of soda and lime are convenient forms for its administration.

Creasote appears to have an operation on the respiratory function, similar to that of chlorine; but, from limited experience with this remedy, I cannot speak confidently of its powers.

4th. *Ventilation.*

Free ventilation is very important in cases of difficult or imperfect respiration. Its advantages are very obvious in dyspnœa and asthma, and in many cases of phthisis, pneumonitis, and other diseases.

A most injurious custom prevails in many places—that of crowding the room of the dangerously sick and dying with friends and acquaintances of the patient. I would not, for slight reasons, object to a custom which to many minds appears sanctified by common association with the solemn-

tionate failure of this faculty, the effects of which remained some time after my general health was restored. The first time I rode out, it was with difficulty and uncertainty that I could remember streets and houses with which I had been most familiar; and on several occasions I even found myself laboring to call to recollection my own name.

ties of death ; but a custom so injurious—so murderous—as this, ought not to be tolerated. To persons in health the impure air of a crowded room is often unpleasant ; and in the diseases just mentioned it commonly occasions distressing sensations to patients. But its most injurious effects are to patients who from unconsciousness or extreme exhaustion cannot express the injury thus occasioned them—the dying, and those in imminent danger of death. Many, very many lives, I have no doubt, are sacrificed to this pernicious custom ; and, in a great proportion of cases, it renders the last moments of life more distressing, and hastens death. When the system is struggling in agony to sustain the respiration, and nature is almost exhausted, the deteriorated air occasioned by surrounding, anxious, sympathizing friends, may turn the scales in which life and death are so equally balanced.

In severe paroxysms of dyspnœa and asthma patients commonly feel the necessity of free ventilation ; and in phthisis I have had many patients insist on having the windows and doors of their rooms kept open, even in the coldest weather of winter. Such cases show the importance of attending to this subject, in the low critical stages of other diseases ; and as a general rule, in such cases, I would advise that a room should be freely opened, while, if the weather is cold, the body is protected with warm but light clothing ; and no persons should be in the room, excepting such as are required to attend the patient.

5th. *Remedies which obviate mechanical impediments to the respiration.*

This indication is sometimes very important in the treatment of diseases attended with deficient respiration. The various mechanical impediments to the respiratory motions, adverted to in a former part of this essay (page 10), should receive careful attention and be obviated if practicable. If, for instance, the respiratory motions are obstructed by water collected within the pleura or peritoneum, calomel, elaterium, digitalis, and other remedies of this class will be appropriate.

One of the most common mechanical impediments to the respiration, in the low stages of typhous and typhoid diseases, is tympanitic distension of the intestinal canal. For this affection various remedies are used, as ether, camphor, capsicum, the pungent aromatics, and the introduction of a flexible tube per anum ; but there is no remedy which I have found so commonly efficacious as the nitrate of silver, exhibited in doses of gr. 1-8 or gr. 1-4, every hour or every two hours.

In dyspepsia, hypochondrias, phthisis, delirium tremens, and other

diseases attended with deficient respiration, injury is often occasioned by tight dress, which confines the motions of the chest.

In dyspnœa, asthma, phthisis, and other diseases, patients frequently complain of inconvenience from the weight of bed clothes. In the low stages of pneumonitis, typhus, and in general when there is extreme exhaustion, with laborious imperfect respiration—as in the dying—the bed clothing should be of the lightest fabric ; and in many cases it is desirable that the clothing should be supported by the hand of an attendant, so as to prevent its pressure on the body of the patient. Under such circumstances, a slight impediment, which in health would occasion no inconvenience, may prove a fatally oppressive load to the system exhausted by disease.

6th. *Remedies which excite secretions vicarious of respiration.*

The bronchial membrane, the liver, skin, kidneys, salivary glands, and the uterus and mammary glands in females—all the secernent organs—are to some extent vicarious in their functions.

The menstrual secretion has an important relation to the respiratory function. In cases of oppressed and deficient respiration, it is not uncommon that this secretion occasions immediate and decided relief.

In some cases of general exhaustion, as in advanced stages of phthisis, it is generally considered as desirable that this secretion should be suspended. The utility of this suspension appears, however, to depend upon other circumstances than simple exhaustion. If with much exhaustion there is a frequent, quick, and irritative pulse, a florid skin, natural wakefulness, and other indications of perfect arterialization of the blood, a continuance of the menstrual secretion is injurious. On the contrary, if the pulse, whether frequent or infrequent, is oppressed; if the lips, the finger nails, and the surface generally, have a livid tinge; if there is a disposition to drowsiness with occasional vertigo and tinnitus aurium; if the exhaustion is complicated with torpor—a torpor occasioned by imperfect respiration—if such are the permanent prevailing symptoms, the menstrual secretion commonly has a favorable effect, and rarely fails to afford at least temporary relief.

I apprehend that the injurious effects of morbidly excessive menstruation have rendered many practitioners over-cautious in regard to the debility which this natural drain of the system is supposed to occasion.

A similar remark appears applicable in reference to the function of *lactation*. Excessive lactation is exhausting; and should be cautiously avoided in the low stages of fever, in phthisis, and other diseases at-

tended with much debility. Yet a sudden suppression of the milk is almost sure to occasion unpleasant nervous symptoms, with oppressed respiration; and in typhous and typhoid fevers, and in some cases of phthisis—notwithstanding a considerable degree of exhaustion—if there are prominent symptoms of oppression of the respiratory and cerebral functions, the secretion should commonly be encouraged.

The skin is well known to perform an office in some degree vicarious of respiration. If the cutaneous secretion is checked, the respiration becomes hurried and laborious; and in cases of oppressed respiration a free perspiration often produces decided relief. These circumstances clearly indicate the importance of attending to the skin, in disorders of the respiratory function. Caution is required, however, in case of disparity between the respiratory and circulating functions, that the remedies exhibited to act on the skin, do not excite arterial action, and thus increase this disparity. Through neglect of this caution, much injury is done by the hot drinks, the external heat, and the general stimulating regimen, commonly employed in domestic and empirical practice, to “sweat” or “steam” a patient, in the commencement of any febrile disease.

The liver also performs a similar important vicarious office. The green discharges, produced by increased action of the liver, which attend a favorable crisis in cholera, are an example of the agency of this organ in depurating the blood. So in congestive fevers free bilious evacuations are almost invariably accompanied with a relief of the subsultus, stupor, coma, livid skin, and other symptoms of imperfect respiration.

Of the remedies which act upon this organ, and thus obviate the effects of imperfect arterialization of the blood, *calomel* is the most important. This remedy, a notice of which has been deferred for this place, on account of this peculiar operation, is one of the most important of the class of remedies, before adverted to, which operate to *excite and invigorate the arterializing nerves*. It appears, indeed, to have an exciting operation on all the organs supplied by the great sympathetic nerve; and hence it produces a general effect on the secretions of the system. Its operations on the liver, the mucous membranes, the skin, and the salivary glands, are well known; and most practitioners must have noticed the relief afforded by calomel in cases of cerebral and general nervous oppression—subsultus, stupor, coma, muttering delirium, &c.—symptoms which, as I have endeavored to show, are commonly connected with imperfect respiration.

CONCLUDING SUMMARY.

The preceding essay, it is believed, establishes several important pathological principles, affording valuable diagnostic and therapeutic indications, which hitherto have been but slightly noticed, or wholly unknown. The indications of the pulse have received much attention; but the variations of the respiration have been little attended to, and the relations between the respiratory and circulating functions have been almost wholly neglected.

The *comparative frequency* of the respiration and the pulse in health, which from constant observation, during a period of several years, I have ascertained to be 1 to $4\frac{1}{2}$ (p. 3), has not been commonly observed; and most of the indications afforded by *variations of this ratio* (p. 5) have been altogether overlooked.

A disproportionate *increased* frequency of the respiration has been shown to afford the general indication (p. 11) that there is some impediment to the respiration; which may be owing to, A. *Disorder of the lungs or air passages* (p. 5), as pneumonitis, phthisis (p. 7), œdema of the lungs (p. 8), or (p. 9) any affection of the lungs which prevents a portion of them from being freely permeated with air, or any disorder of the bronchia or bronchial membrane which impedes the communication between the air and the blood within the lungs: or, B. *Some mechanical impediment* to the motions of respiration (p. 10): or, C. *Imperfect function of the organic nerves* of the lungs (p. 10).

A disproportionate *diminished* frequency of the respiration, which indicates a *want of energy in the nerves which control the respiratory motions* (p. 11), has been shown to be common in typhous fever, and in many other diseases.

The pathological effects of imperfect aeration of the blood, which had been treated of by Bichat and some subsequent writers (p. 12), but which they scarcely noticed except as immediate precursors and causes of death, I have observed to be manifest through the progress of typhous fever (p. 14), and many other diseases. What is commonly termed *congestion in the brain*, I have endeavored to show (p. 17), is simply a deterioration of the blood caused by this imperfect aeration, a prominent example of which occurs in the disease termed congestive typhus (p. 17). The effects of this imperfect aeration, depending upon disordered function of the different nerves concerned in respiration, have been traced in various diseases (p. 14 to p. 25).

The common occurrence, and the injurious effects, of this imperfect aeration of the blood suggest the important general *therapeutic indication* (p. 26) *to remedy deficient respiration*. The medicinal agents are detailed (p. 26 to p. 28) which aggravate deficient respiration, by increasing the circulation, or by diminishing the respiratory function.

The use of remedies, with a view *to promote the arterialization of the blood* (p. 28), it is believed, has never been distinctly treated of by any author, as a prominent object of medication. Though my 1st class of these remedies—those which diminish the action of the heart and arteries (p. 29)—have been commonly known to possess this power over the circulation, still they have not been commonly employed with the view—a view which I consider as highly important in many cases—to obviate a disparity between the respiratory and circulating functions. The 2d and 3d classes of remedies (p. 34 and p. 36)—those which excite and invigorate the motor respiratory nerves, and the arterializing nerves of the lungs—have rarely, if ever, been recommended for those particular purposes; though I think it will be obvious to my readers, that many of the known valuable effects of these remedies are owing to such operations. The other three classes—4th. Ventilation (p. 42); 5th. Remedies which obviate mechanical impediments to the respiration (p. 43); and, 6th. Remedies which excite secretions vicarious of respiration (p. 44)—though their general effects on the respiratory function have been known, have not been commonly employed for the distinct purpose of obviating deficient aeration of the blood.

In short, the general subject of the pathological relations between the respiratory and circulating functions has received little, very little attention. The writer hopes that he has at least shown the subject to be deserving of investigation.

